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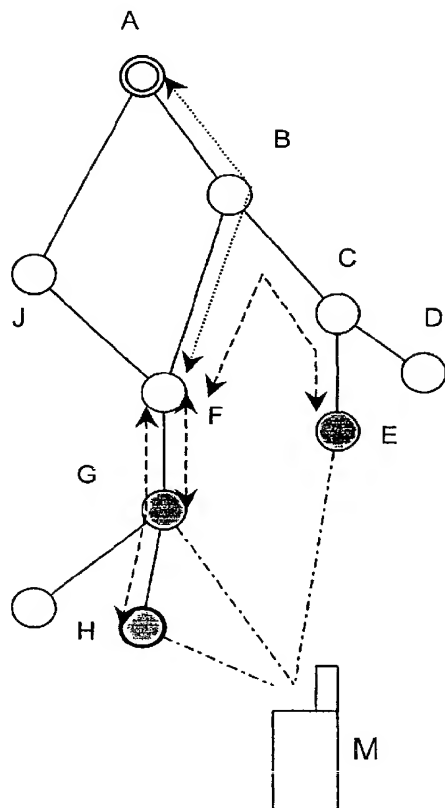
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(54) Title: METHOD AND NETWORK NODE FOR SELECTING A COMBINING POINT



(57) **Abstract:** The present invention relates to a method and network device for selecting a combining point at which at least two redundant transmission paths are combined to a single transmission path in a transmission network comprising at least two select-able combining points (B - J). The combining point is selected by a method using at least two measurement-based selection criteria to which different priorities are allocated. The selection result of a selection criterion with a higher priority is used as a constraint for a selection based on a selection criterion with a lower priority. The selection criteria are applied to lengths or loads of the redundant transmission paths or the single transmission path. Thereby, an optimized combining point can be obtained to thereby lower delays for combined traffic and increase efficiency of network utilization.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method and Network Node for Selecting a Combining Point

FIELD OF THE INVENTION

The present invention relates to a method and network node for selecting a combining point, e.g. a Macro Diversity Combining (MDC) point, at which at least two
5 redundant transmission paths are combined to a single transmission path in a transmission network, such as a radio access network (RAN) providing access to an Internet Protocol (IP) based network architecture, comprising at least two selectable combining points.

BACKGROUND OF THE INVENTION

10 In a Code Division Multiple Access (CDMA) based cellular network all users in the same cell or in different cells may share the same frequency spectrum simultaneously. In spread spectrum transmission, the interference tolerance enables universal frequency reuse. This enables new functions such as soft handover, but also causes strict requirements on power control. Due to the universal frequency reuse,
15 the connection of a radio terminal, e.g. a mobile terminal, mobile station or user equipment to the cellular network can include several radio links. When the radio terminal is connected through more than one radio link, it is said to be in soft handover. If, in particular, the radio terminal has more than one radio link to two cells on the same side, it is in softer handover. Soft handover is a form of diversity, increasing the signal-to-noise ratio when the transmission power is constant. At
20 network level, soft handover smoothes the movement of a mobile terminal from one cell to another. It helps to minimize the transmission power needed in both uplink and downlink.

Thus, a radio terminal of a network subscriber can transmit the same information
25 on a plurality of redundant transmission parts that are set up parallel via a radio transmission interface from the cellular network to the radio terminal or from the radio terminal to the cellular network in order to achieve an optimal transmission quality. Such a transmission structure is called macro diversity. The redundant transmission paths can be dynamically setup and cleared down while the radio
30 terminal changes its location. The information sent out by the radio terminal in the transmission frames on various transmission paths can be merged in the transmission network at combination points at which respectively two transmission paths are combined into a single transmission path in one transmission direction

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(uplink) and the single transmission path is divided into two transmission paths in the other transmission direction (downlink). A corresponding network architecture is described for example in the US 6,198,737 B1.

5 In order to obtain the most efficient RAN architecture, which is based on using advantageous characteristics of IP, some functionality is relocated between network elements. According to a recent new RAN architecture, a network element known as Base Station Controller (BSC) or Radio Network Controller (RNC) is no longer required, although this functionality must remain in the RAN architecture. Therefore, the location of a combining point, e.g. MDC point, can no longer be central-
10 ized for all base stations in the RAN. Consequently, some RNC functionality has been transferred to the base stations in order to enable soft handover and associated signaling to happen along the shortest path, producing minimum delay and signaling load to those paths of the network where this is not necessary. This new RAN architecture is described e.g. in the White Paper "IP-RAN, IP - the future of
15 mobility", Nokia Networks, 2000.

In such a new RAN architecture, the MDC point can be selected dynamically e.g. by a serving base station instead of having this functionality in one pre-selected point like the RNC in the conventional RAN architecture or in the base station that
20 initiates the call. In the new RAN architecture, base stations are able to act as MDC points. However, it should be possible to limit this set in order to reduce the number of MDC point relocations, which introduce additional delay, i.e., only some base stations can act as MDC points if needed. Those base stations are called MDC-capable base stations or simply MDC-capable BTSs.

However, if the first common upstream base station, i.e. the base station closest to
25 the radio network gateway on the common path from a serving base station towards any drift base station, is always selected as the MDC point for the base stations that participate in soft handover, the processing load of the MDC point might be too high and network resources are not optimized. Moreover, it might be desired to perform link load balancing by selecting a more appropriate base station
30 as the MDC point.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and network node for selecting a combining point in a transmission network, by means of which

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the load at the combining point can be reduced and a more efficient network utilization can be achieved.

This object is achieved by a method of selecting a combining point at which at least two redundant transmission paths are combined to a single transmission path in a transmission network comprising at least two selectable combining points, said method comprising the steps of:

5 using at least two measurement-based selection criteria for selecting said combining point;

allocating different priorities to said at least two selection criteria; and

10 using the selection result of a selection criterion with a higher priority as a constraint for a selection based on a selection criterion with a lower priority.

Furthermore, the above object is achieved by a network node for selecting a combining point at which at least two redundant transmission paths are combined to a single transmission path in a transmission network comprising at least two selectable combining points, said network node being arranged to use at least two

15 measurement-based selection criteria with different priorities for selecting said combining point, and to use the selection result of a higher priority selection criterion as a constraint for a selection based on a lower priority selection criterion.

Accordingly, the combining point location is optimized based on a goal functionality, e.g. a preemptive method, which works in such a fashion that an optimal solution to a highest priority goal is searched and this solution is added as a new constraint for lower priority goals. If the solution for a higher priority goal leads to a single combining point, lower priority goals may not have to be considered. Such a preemptive method is advantageous in that it always results in an optimum value

20 for the highest priority goal. Moreover, only a decision regarding the priority order of the available different goals is required, while no weights have to be determined. Thereby, lower delays for MDC traffic and a more efficient network utilization can be obtained due to the optimized location of the combining point.

Preferably, the at least two selection criteria comprise a selection criterion applied to measured lengths or loads of the at least two redundant transmission paths and/or the single transmission path. Furthermore, the at least two selection criteria

30 may comprise a selection criterion applied to measured processing loads of the selectable combining points. In particular, the at least two selection criteria may comprise a first criterion of minimizing the maximum length of the at least two re-

dundant transmission paths, a second criterion of minimizing the maximum total length of the at least two redundant transmission paths and the single transmission path, a third criterion of minimizing the maximum traffic load on the at least two redundant transmission paths and the single transmission path, and a fourth
5 criterion of minimizing the processing load of the combining point. The maximum length and maximum total length may be determined by counting hops of said single and redundant transmission paths, respectively. Furthermore, the highest priority may be allocated to the first criterion, the second highest priority to the second criterion, the third highest priority to the third criterion, and the lowest priority
10 to the fourth criterion. The third criterion may be applied by monitoring and updating real time traffic loads using an averaging function, e.g. an exponential averaging function.

Thus, the role of load measurements, used for measuring both link loads and combining point processing loads, is emphasized in selecting the optimal combining
15 point. This provides the advantage that both link loads and combining processing loads can be balanced by selecting the optimal combining point.

The load measurements results may be transmitted mutually between the at least two selectable combining points at predetermined intervals. Alternatively, the load measurement results or load reports may be transmitted from the at least two selectable combining points to a centralized resource , which will distribute the load
20 information to all possible combining points at predetermined intervals. As a further alternative, the load reports may be transmitted from the at least two selectable combining points directly to all other possible combining points at predetermined intervals without any intervention of a centralized resource. In this connection, load measurement results refers to „raw data“ from router statistics while load
25 report contains already processed information.

Furthermore, maximum load thresholds may be set to be considered during the selection of the combining point. The maximum real time load threshold may define the maximum allowable real time load on used links of the at least two redundant transmission paths and other (class x) load thresholds may define the maximum allowable load for different traffic types (e.g., streaming) on the single transmission path. Furthermore, a maximum load threshold may be provided for defining the maximum allowable processing load in the selected combining point.
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A selection criterion may be bypassed if the required measurement values are not available.

If the selection method does not lead to a selection of a combining point, a redundant transmission path may be dropped from the at least two redundant transmission paths. Finally, if only one redundant transmission path is left and the method still does not lead to a selection of a combining point, the corresponding call may invoke one of some not yet mandated actions. For example, the possible actions may be (1) using the remaining base station in the active set of the on-going call as the new serving BTS or (2) keeping the current MDC point of the on-going call unchanged or (3) rejecting the new call (new call means that connection hasn't been set up yet) as a whole.

The selection method may be used after a change of the network topology.

The combining point may be an MDC point, if the selection method is used in a universal radio access network for providing access to an IP-based network. In this case, the selectable combining points may be base station devices. The network node for performing the selection method may be e.g. a base station device or centralized resource managing device.

Additionally, a combining point validity checking functionality may be applied, wherein a previously selected combining point is maintained if the previously selected combining point at least still meets the at least two measurement-based selection criteria. The checking functionality can be modified such that at least one stricter selection criterion is applied to the previously selected combining point. As an example, the at least one stricter selection criterion may correspond to 90% of a load threshold value applied to the previously selected combining point.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the present invention will be described in greater detail based on a preferred embodiment with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic diagram of a radio access network topology in which the present invention can be implemented;

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Fig. 2 shows a flow diagram indicating a selection method according to the preferred embodiment of the present invention;

Fig. 3 shows an algorithm for a first selection criterion according to the preferred embodiment;

5 Fig. 4 shows an algorithm for a second selection criterion according to the preferred embodiment;

Fig. 5 shows an algorithm for a third selection criterion according to the preferred embodiment;

10 Fig. 6 shows an algorithm for a fourth selection criterion according to the preferred embodiment; and

Fig. 7 shows a table indicating combining processing loads and real time traffic loads according to a specific implementation example.

DESCRIPTION OF THE PREFERRED EMBODIMENT

15 The preferred embodiment will now be described on the basis of a new RAN network architecture for providing access to an IP network.

According to Fig. 1, a mobile terminal M is connected to a RAN via three redundant transmission paths indicated by respective dash-dot lines. The RAN architecture comprises a plurality of network nodes A to J, wherein the shaded nodes E, G and H are currently connected to the mobile terminal M via the redundant transmission paths. In particular, the network node H indicated with the bold circle is
20 used as the serving base station, i.e. the base station terminating the core network interfaces data stream, and performing Radio Resource Management (RRM) functions like scheduling, power control and the like. In contrast thereto, the other shaded base stations G and E are used as drift base stations providing only re-
25 sources and radio L1 layer functions for the respective connections to the mobile terminal M.

In the RAN topology shown in Fig. 1, contrary to conventional RANs, most of the functions of the former centralize controller (RNC or BSC) are moved to the base stations. In particular, all radio interface protocols are terminated in the base sta-

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tions. Entities outside the base stations are needed to perform common configuration and some radio resource functions, or interworking with legacy, gateways to a core network, etc. An interface is needed between the base stations, supporting both control plane signaling and user plane traffic. Full connectivity among the entities may be supported over an IPv6 (Internet Protocol version 6) transport network. The network node A indicated by a double circular line corresponds to a RAN Gateway (RNGW), which is the IP user plane access point from the IP-based core network or other RAN to the present RAN. During a radio access bearer assignment method, the RAN returns to the core network transport addresses owned by the RNGW A where the user plane shall be terminated. Additionally, packet-switched and circuit-switched interfaces are connected through the RNGW A. The main function of the RNGW A is a micro-mobility anchor function, i.e. the user plane switching during the relocation/handover of base stations, in order to hide the mobility to the IP-based core network. Due to this function, the RNGW A does not need to perform any radio network layer processing on the user data, but relays data between the RAN and IP tunnels of the IP-based core network. Thus, the RNGW A is responsible for the association between RAN tunnels and core network tunnels, setup and release of tunnel endpoints, user plane traffic switching, packet relaying, mapping between tunnel endpoint IDs, and firewall/security functions. It is noted that several RNGWs may be provided in the RAN to guarantee a flexible relationship between the RNGWs and the base stations.

In the situation shown in Fig. 1, the network node F has been selected as the MDC point for the connections to the mobile terminal M. The dashed arrows indicate the MDC legs between the serving and drift base stations H, G and E and the MDC point F. Furthermore, the dotted arrow between the MDC point F and the RNGW A indicates the single transmission path to which the redundant transmission paths are combined. Thus, the term "MDC leg" refers to the path from the MDC point F to one of the drift and serving base stations H, G and E.

According to the preferred embodiment, a measurement-based method is provided for selecting the most appropriate MDC point among the network nodes, e.g. base stations B to J in the IP-based RAN. To achieve this, the MDC point location is optimized using a goal programming e.g. by first minimizing the maximum MDC leg length, then minimizing the total hop count of MDC legs and the paths from the RNGW A to the MDC point, then minimizing the maximum real time traffic load on used links, and finally minimizing the MDC processing load at the potential MDC point.

It is noted that the term "real time traffic" refers to packets marked with certain differentiated services code points, e.g. Expedited Forwarding (EF) which indicates a high priority Per-Hop Behavior (PHB) to achieve a high-quality virtual circuit service. The term "hop" is used to denote a path between two network nodes, that
 5 does not have any significant effect on the characteristics of traffic flows. Thus, a connection path between two neighbor network nodes in Fig. 1 corresponds to one hop. The PHB is an externally observable forwarding treatment of an aggregate traffic stream in a network node.

Real time traffic loads on all links are monitored and updated by using exponential
 10 averaging according to the following equation:

$$rt_load_i = (1-w)*rt_load_{i-1} + w*(rt_bits/(p*link_bw)), \quad (1)$$

wherein rt_bits denotes the number of real time bits sent on an output link, $link_bw$ denotes the output link bandwidth, which may be both obtained from router statistics, w denotes an exponential averaging weight, and p denotes a measurement
 15 period. An appropriate value for p could be e.g. 500 ms. The value for w depends on the desired reaction time to changes in link loads, e.g. $w = 0.5$. A similar averaging mechanism may be applied to all other relevant link loads.

Furthermore, the ratio of on-going MDC connections and the maximum number of MDC connections could be monitored for every base station. The corresponding
 20 threshold values may vary considerably between different base stations. E.g., star points should be able to handle more MDC connections than a base station at the end of a chain. Here, instantaneous values could be used instead of the above exponential averaging.

The number of MDC connections running in a particular base station and traffic
 25 load information on all links directly attached to this particular base station may be transmitted periodically, e.g. every p ms, as measurement results to other base stations. To avoid excessive traffic, a multicasting-like approach (e.g., Spanning Tree based algorithm) could be used. Furthermore, the value of the parameter p could be increased if the number of base stations is increased in the RAN
 30 architecture.

Alternatively, if a centralized IP Transport Resource Manager (ITRM) or bandwidth broker is provided, each base station could send its measurement results to the

ITRM only. The ITRM (not shown in Fig. 1) would then use a multicast-like approach to periodically distribute "aggregate" load reports to all MDC-capable base stations. If a centralized resource is not used for the load reports distribution, any BTS in RAN then sends its load report directly to all other MDC-capable BTSs at predetermined intervals, where a multicasting-like approach may be used for the sending. In any way, the messages containing the measurement results or load reports should be given a high priority in terms of packet delay and loss, e.g. by marking them with an appropriate differentiated services code point (e.g. EF).

Furthermore, it is assumed that all network nodes of the RAN network have a "helicopter view" of the network topology. This can be achieved, for example by using OSPF (Open Shortest Path First) routing protocol, as described in John T. Moy, "OSPF: Anatomy of an Internet Routing Protocol, 3rd printing, September 1998, ISBN 0-201-63472-4. In this respect, it will be noted that only a single (shortest) path is in use between two network nodes if basic OSPF is used. Nevertheless, load balancing can be performed by choosing an appropriate MDC point.

The following priority order may be given to the above goals or selection criteria for selecting the appropriate MDC point. The highest priority may be allocated to the goal of minimizing the maximum MDC leg length. The second highest priority may be allocated to the goal of minimizing the total hop count of MDC legs and the paths from the RNGW A to the MDC point. The third highest priority may be allocated to the goal of minimizing the maximum real time traffic load on used links. Finally, the lowest priority may be allocated to the goal of minimizing of the MDC processing load, e.g. the number of on-going connections divided by some predetermined threshold value.

Additionally, at least one of the following general constraints may be set. The maximum real time traffic load on MDC legs (*max_rt_load*) should be less or equal than a real time threshold value (*rt_threshold*). Maximum class x (traffic class of packets sent from RNGW; can be real time as well) traffic load on the path between RNGW and MDC point candidate (*max_x_load*) should be less or equal than a class x threshold value (*x_threshold*). Furthermore, the MDC processing load in the MDC point candidate (*mdc_load*) should be less than MDC threshold value (*mdc_threshold*).

Fig. 2 shows a flow diagram indicating an implementation of the selection processing according to the preferred embodiment, in which the above goals and param-

ters are used. Furthermore, in the following the running variable N denotes the number of MDC point candidates, e.g. base stations in the RAN architecture, and the running variable M denotes the number of drift base stations participating in a particular soft handover situation.

- 5 The separate flow diagram on the upper right portion of Fig. 2 indicates a method for distributing individual measurement results obtained at the base stations either to the other base stations in the RAN or to the central ITRM node (not shown in Fig. 2), after an exponential averaging with a weight parameter w has been applied to the measured link loads, and a timer has expired. Furthermore, another
10 separate flow diagram is indicated below the above described separate diagram, wherein this lower flow diagram indicates a processing for updating the MDC processing load in the MDC point candidates whenever a new MDC connection starts or a MDC connection is dropped. These two partial or sub-methods are continuously performed in the background or in parallel to the following main selection
15 method starting at the upper left side of Fig. 2.

When a request for a new call or some other trigger arrives at a serving base station (IP BTS), the first selection criterion is applied in step 1, wherein the maximum MDC length is minimized. Then, the selection result is compared to the general
20 constrains, e.g. real time threshold, class x threshold and/or MDC threshold. If these constrains are not met, it is checked whether multiple base stations are left. If so, the base station with the worst radio connection to mobile phone is dropped and the selection method based on the first criterion with the highest priority is repeated. If a single base station is left and the constraints are still not met, the call is rejected – if it is a new call. In the case of an on-going call, we continue the call
25 without soft handover (keeping its current MDC point unchanged or with the remaining BTS acting as serving BTS).

If general constrains are met, it is checked whether a single MDC point has been obtained by the first selection operation. If so, this single MDC point is output as the best or appropriate MDC point. If not, the second selection criterion with the
30 second highest priority is applied in step 2 using the additional constraint or result of the selection in step 1.

Fig. 3 shows an example for an algorithm corresponding to the highest priority selection criterion in step 1. Initially, minimum and maximum MDC hop counts are set, e.g. 100. Then, it is checked for every MDC point candidate, whether the MDC

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threshold, class x threshold and the real time threshold constraints are met. If so, the maximum hop count is set to the hop count of the path between the candidate and the serving base station, i.e. the length of the redundant transmission path. Then, it is checked for all drift base stations, whether the hop count between the candidate and the drift base station is larger than the set maximum hop count. If so, the maximum hop count is set to the hop count between the candidate and the drift base station. If the resulting maximum hop count is smaller or equal than the set minimum hop count, the minimum hop count is set to the obtained maximum hop count. If the obtained maximum hop count is larger than the set minimum hop count, the candidate is dropped from the MDC point candidate list. Furthermore, if the initial threshold constraints are not met for the actual candidate, it is also dropped from the MDC point candidate list.

In step 2 of Fig. 2, the number of total hops of the MDC candidates obtained from the first criterion in step 1 is minimized. If a single MDC point is obtained as the result of the second criterion, it is output as the best or appropriate MDC point.

Fig. 4 shows an algorithm as an example of the selection method according to the second criterion with the second highest priority. Initially, a minimum hop count is set to a predetermined value, e.g. 100. Then, a total hop count of all paths between the candidate and the serving and drift base stations and between the RNGW A and the candidate is determined for each remaining candidate and compared to the minimum hop count. If the obtained hop count of a candidate is smaller or equal than the minimum hop count, the minimum hop count is set to the hop count of the candidate. If not, the candidate is dropped from the list of remaining MDC point candidates.

In step 3 of Fig. 2, the third criterion with the third highest priority is applied by minimizing the maximum real time traffic load for the MDC point candidates obtained from step 2. If the result of step 3 leads to a single MDC point, this single MDC point is output as the best or appropriate MDC point. If not, the fourth criterion with the lowest priority is applied in step 4.

Fig. 5 shows an example of an algorithm, which may be used in step 3. Initially, a minimum value for the maximum load is set to a predetermined value, e.g. 1. Then, for every remaining MDC point candidate of the list, a maximum load value is obtained by calculating the maximum of the real time loads in both directions for all redundant transmission paths between the serving and drift base stations and

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the candidate and for the single transmission path between the candidate and the RINGW A. If the obtained maximum real time load value of the candidate is smaller or equal than the set minimum load value, the minimum load value is set to the obtained maximum real time load value of the candidate. If not, the candidate is
5 dropped from the MDC point candidate list.

In step 4 of Fig. 2, the fourth criterion with the lowest priority is finally applied by minimizing the MDC processing load for all remaining MDC point candidates.

Fig. 6 shows an example of an algorithm, which can be used in step 4. Initially, a minimum MDC load is set to a predetermined value, e.g. 1. Then, for every re-
10 maining candidate in the MDC point candidate list, it is checked whether the MDC load of the candidate is smaller than the set minimum MDC load. If so, the minimum MDC load is set to the MDC load of the candidate. If not, the candidate is dropped from the MDC point candidate list.

If the result of step 4 in Fig. 2 indicates a single MDC point, this single MDC point
15 is output as the best or appropriate MDC point. If not, a single MDC point may be randomly selected among the final remaining candidates on the MDC point candidate list, and output as the best or appropriate MDC point.

Thus, a goal based selection method for obtaining a single appropriate MDC point is provided which can be used at any initialization of a new call.

20 In case of any missing information, e.g. link loads or the like, the corresponding selection step requiring the missing information can be bypassed. If topology information is missing at the network node where the MDC point selection is performed, the serving base station can be used as the MDC point. However, any other selection is possible, of course.

25 The proposed MDC point selection method may as well be applied or initiated in cases where the network topology or the set of serving and drift base station has changed.

Fig. 7 shows a table indicating an example of measured real time traffic loads (percentage of link capacity) towards neighbor nodes, wherein a maximum or real
30 time traffic load may be set to 80% (in this example, all traffic is real time traffic). Furthermore, the table in Fig. 7 shows respective MDC loads of each network

nodes shown in the architecture of Fig. 1. In particular, the table of Fig. 7 presents measurement information to be used in addition to the network topology information, which each base station B to J has available for applying the selection criteria for selecting the MDC point.

- 5 In the following, the above described selection method is applied using the topology of Fig. 1 and the measurement results of Fig. 7.

In the first criterion according to Fig. 3, the minimum value of the maximum MDC leg length will finally be set to three hops. Thus the nodes B and F will be the remaining MDC point candidates in the candidate list. Only these two network nodes
10 satisfy the criteria that the maximum length of the MDC legs is not higher than the minimum value, i.e. three hops.

Then, the second criterion according to the algorithm in Fig. 4 leads to eight hops as the minimum value of the total hop count. Still, both network nodes B and F satisfy this second criterion and thus remain on the candidate list. Accordingly, the
15 result of the topology-based first and second selection criteria leads to a candidate list comprising the network nodes B and F.

As regards the third criterion according to Fig. 5, the maximum real time load is 60% obtained on the link from node B to node C. However, this link is comprised in the transmission paths of both MDC point candidates. Thus, still both candi-
20 dates remain on the candidate list.

According to the final fourth criterion, the individual MDC processing loads of the remaining MDC point candidates are compared, wherein the MDC processing load of the candidate node F (55%) is substantially lower than the MDC processing load of the candidate node B (70%). Thus, step 4 in Fig. 2 leads to a single MDC
25 point, i.e. network node F, which will be output as the best MDC point. This result corresponds to the situation shown in Fig. 1.

Due to the fact that the suggested selection method leads to an optimized MDC point with minimized load values and link lengths, lower delays for MDC traffic and more efficient network utilization can be achieved. Furthermore, the method is
30 simple enough to be implemented within the base stations. However, in case the required scalability leads to a problem in bigger RAN topologies, multicast-like transmission should be provided. Additionally, a scheme suitable to distribute the

measurement results either through a centralized resource or in a distributed manner among the network nodes is needed if e.g. traffic loads or MDC processing loads are used in the MDC point selection process.

5 However, the method and system for finding an optimized MDC point location, as proposed above, might lead to an excessive amount of MDC relocations, which is not desirable. Moreover, heavy calculations are required in connection with each MDC relocation. To alleviate this problem, a validity checking functionality can be introduced to reduce the number of MDC relocations in the RAN. According to the validity checking functionality, the MDC point or functionality will not be moved or
10 relocated to a possibly better location, if the current MDC point is still valid, i.e., if the initial or slightly stricter constraints are still met. For example, the set maximum load threshold could be slightly reduced.

Thereby, the amount of MDC point calculations and relocations can be reduced to those cases where the location of the current MDC point no longer meets the pre-
15 set constraints.

The validity checking functionality can be activated each time there is a change in the active set of base stations. When the MDC point calculation is triggered, the MDC point validity checking functionality will first check whether or not the current MDC point meets the constraints. If the answer is yes, no further calculations are
20 done and the MDC functionality is not relocated – even though the active set of base stations would need to be updated. In logical terms, the validity checking functionality can be expressed as indicated in Fig. 8. It is noted that the way how the constraints (initial or stricter) are checked depends on the used MDC point selection method.

25 Fig. 9 shows a corresponding enhancement of the flow diagram of Fig. 2, to incorporate the above validity checking functionality. In particular, the validity checking functionality is incorporated in step 0 and the subsequent conditional branch operation, which are only performed if the set of base stations, e.g. IP BTSs, has changed.

30 Fig. 10 shows a specific example of the logical expression of Fig. 8, wherein a slightly stricter constraint, i.e. 90% of load threshold, is applied to the current MDC point. Of course, any other percentage can be applied to implement a lower

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threshold and thus a stricter constraint. Furthermore, stricter threshold values may as well be applied to one or all other MDC point selection constraints.

5 In the example of Fig. 7, it is now assumed that node G corresponds to the current MDC point which had been selected previously. With the above additional validity checking functionality, this current or old MDC point (node G) would be selected again or maintained, instead of node F, in the example of Fig. 7, because the constraints were still met. However, in this case, only a simple check of the load value in the MDC load column of the table of Fig. 7 was required. Hence, in addition to
10 dramatically reducing the number of MDC relocations, the proposed validity checking functionality will considerably reduce the amount of MDC point selection calculations done at the base stations.

15 It is noted that the present invention is not restricted to the above preferred embodiments, but can be used in any network environment where a plurality of redundant transmission paths are combined at a combining point to a single transmission path. Furthermore, the method is not restricted to the specific selection criteria indicated in the above steps 1 to 4. Any selection criterion suitable for obtaining an appropriate combining point can be used in the priority based selection
20 method. Moreover, the allocation of the priorities may be changed in any manner suitable to obtain a combining point appropriate to a particular application. Thus, the preferred embodiments may vary within the scope of the attached claims.

Claims

1. A method of selecting a combining point at which at least two redundant transmission paths are combined to a single transmission path in a transmission network comprising at least two selectable combining points (B - J),
5 said method comprising the steps of
 - a) using at least two measurement-based selection criteria for selecting said combining point;
 - b) allocating different priorities to said at least two selection criteria; and
 - 10 c) using the selection result of a selection criterion with a higher priority as a constraint for a selection based on a selection criterion with a lower priority.
2. A method according to claim 1, wherein said at least two selection criteria
15 comprise a selection criterion applied to measured lengths or loads of said at least two redundant transmission paths and/or said single transmission path.
3. A method according to claim 1 or 2, wherein said at least two selection criteria comprise a selection criterion applied to measured processing loads of said selectable combining points.
4. A method according to claim 2 or 3, wherein said at least two selection criteria
20 comprise a first criterion of minimizing the maximum length of said at least two redundant transmission paths, a second criterion of minimizing the maximum total length of said at least two redundant transmission paths and said single transmission paths, a third criterion of minimizing the maximum
25 traffic load on said at least two redundant transmission paths and said single transmission path, and a fourth criterion of minimizing the processing load of said combining point.
5. A method according to claim 4, wherein said maximum length and maximum total length are determined by counting hops of said single and redundant transmission paths, respectively.
- 30 6. A method according to claim 4 or 5, further comprising the step of allocating the highest priority to said first criterion, the second highest priority to said

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second criterion, the third highest priority to said third criterion, and the lowest priority to said fourth criterion.

- 5 7. A method according to any one of claims 4 to 6, wherein said third criterion is applied by monitoring and updating real time traffic loads using an averaging function.
8. A method according to claim 7, wherein said averaging function is an exponential averaging function.
- 10 9. A method according to any one of the preceding claims, further comprising the step of transmitting load measurement results or load reports mutually between said at least two selectable combining points (B - J) at predetermined intervals.
- 15 10. A method according to any one of claims 1 to 8, further comprising the step of transmitting load measurement results from said at least two selectable combining points (B - J) to a centralized resource, which will distribute the load information to all possible combining points (B - J) at predetermined intervals.
- 20 11. A method according to any one of claims 1 to 8, further comprising the step of transmitting load reports from said at least two selectable combining points (B - J) directly to all other possible combining points (B - J) at predetermined intervals without any intervention of a centralized resource.
- 25 12. A method according to any one of the preceding claims, further comprising the step of setting a maximum load threshold to be considered during said selection of said combining point.
13. A method according to claim 12, wherein said maximum load threshold defines the maximum allowable real time load on used links of said at least two redundant transmission paths and/or the maximum allowable class x load on used links of said single transmission path.
- 30 14. A method according to claim 12 or 13, wherein said maximum load threshold defines the maximum allowable processing load in said selected combining point.

15. A method according to any one of the preceding claims, further comprising the step of bypassing a selection criterion if required measurement values are not available.
- 5 16. A method according to any one of the preceding claims, further comprising the step of dropping a redundant transmission path from said at least two redundant transmission paths, if said method does not lead to a selection of a combining point.
- 10 17. A method according to claim 16, further comprising the step of rejecting a corresponding new call if only one redundant transmission path is left and said method does not lead to a selection of a combining point.
18. A method according to any one of the preceding claims, wherein said selection method is used after a change in the network topology.
- 15 19. A method according to any one of the preceding claims, wherein a previously selected combining point is maintained if said current combining point at least still meets said at least two measurement-based selection criteria.
- 20 20. A method according to claim 19, wherein at least one stricter selection criterion is applied to said previously selected combining point.
21. A method according to claim 20, wherein said at least one stricter selection criterion corresponds to 90% of a load threshold value applied to said previously selected combining point.
- 25 22. A network node for selecting a combining point at which at least two redundant transmission paths are combined to a single transmission path in a transmission network comprising at least two selectable combining points (B - J), said network node being arranged to use at least two measurement-based selection criteria with different priorities for selecting said combining point, and to use the selection result of a higher priority selection criterion as a constraint for a selection based on a lower priority selection criterion.
- 30 23. A network node according to claim 22, wherein said combining point is a macro diversity combining point in a radio access network providing access to an IP-based network.

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24. A network node according to claim 23, wherein said selectable combining points are base station devices (B – J).
25. A network node according to any one of claims 22 to 24, wherein said network node is a base station device (B – J).
- 5 26. A network node according to any one of claims 22 to 24, wherein said network node is a centralized resource managing device.

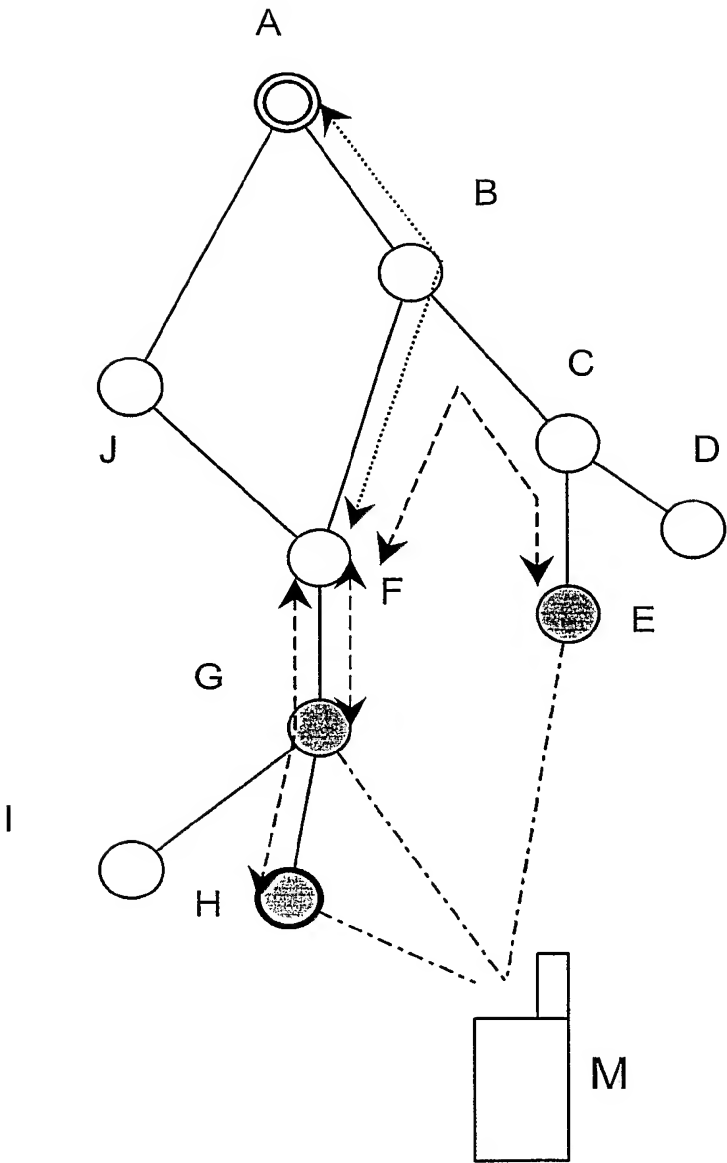


Fig. 1

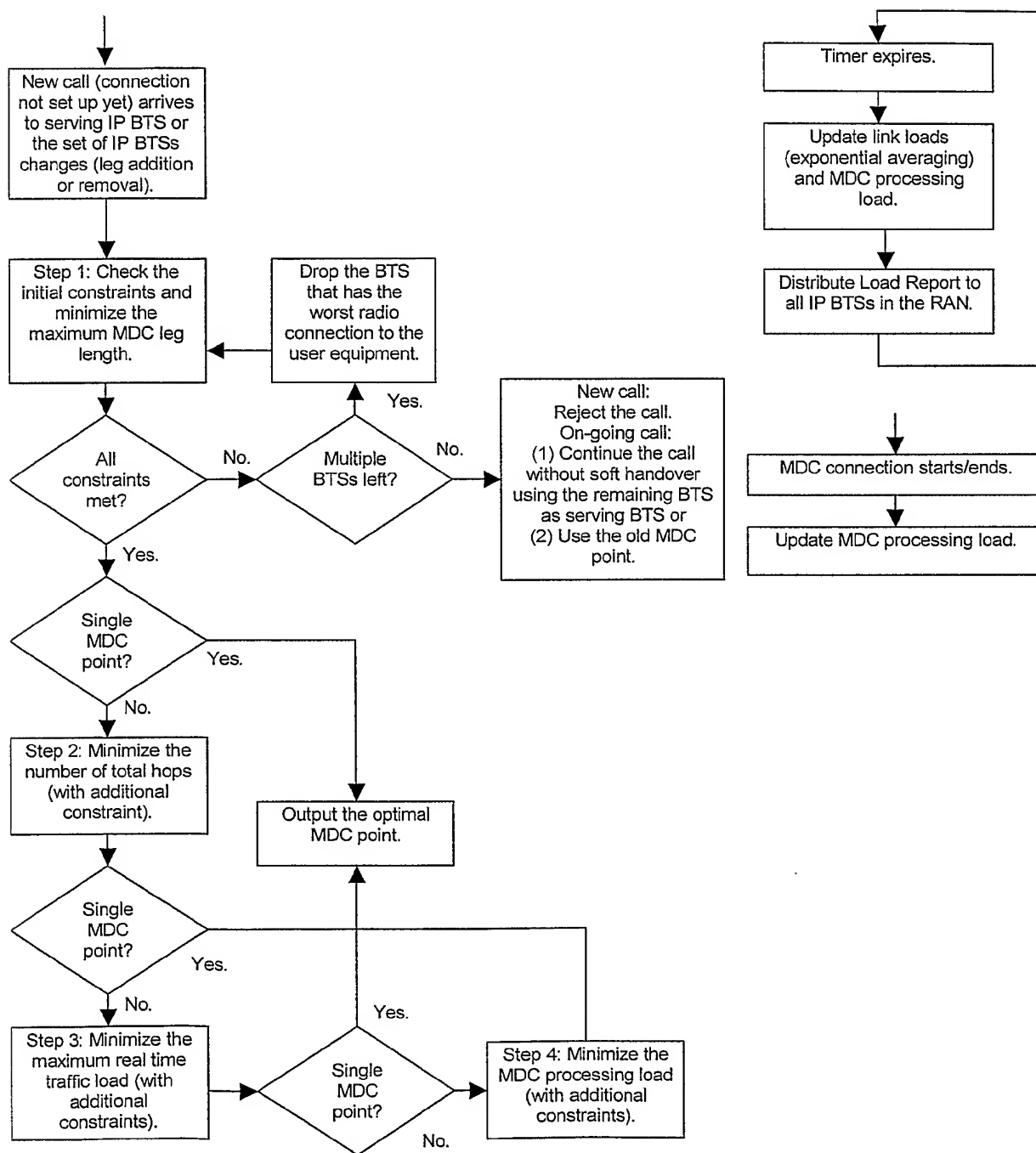


Fig. 2

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mdc_hop_countmin = 100 (or some other initialization)
for i = 1 to N
  if (mdc_loadCANDIDATE(i) < mdc_threshold AND max_rt_loadCANDIDATE(i) ≤ rt_threshold
    AND max_x_loadCANDIDATE(i) ≤ x_threshold)
    mdc_hop_countmax(i) = hop_countCANDIDATE(i)->SERVING_BTS
    for j = 1 to M
      if (mdc_hop_countCANDIDATE(i)->DRIFT_BTS(j) > mdc_hop_countmax(i))
        mdc_hop_countmax(i) = hop_countCANDIDATE(i)->DRIFT_BTS(j)
    if (mdc_hop_countmax(i) ≤ mdc_hop_countmin)
      mdc_hop_countmin = mdc_hop_countmax(i)
    else
      drop candidate i from the MDC point candidate list
  else
    drop candidate i from the MDC point candidate list
for i = 1 to N (excluding already dropped candidates)
  if (mdc_hop_countmax(i) > mdc_hop_countmin)
    drop candidate i from the MDC point candidate list

```

Fig. 3

```

hop_countmin = 100 (or some other initialization)
for i = 1 to N (excluding already dropped candidates)
  hop_countCANDIDATE(i) = hop_countRNGW->CANDIDATE(i) + hop_countCANDIDATE(i)->SERVING_BTS
  for i = 1 to M
    hop_countCANDIDATE(i) = hop_countCANDIDATE(i)->DRIFT_BTS(j)
  if (hop_countCANDIDATE(i) ≤ hop_countmin)
    hop_countmin = hop_countCANDIDATE(i)
  else
    drop candidate i from the MDC point candidate list
for i = 1 to N (excluding already dropped candidates)
  if (hop_countCANDIDATE(i) > hop_countmin)
    drop candidate i from the MDC point candidate list

```

Fig. 4

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```

max_rt_loadmin = 1 (or some other initialization)
for i = 1 to N (excluding already dropped candidates)
    max_rt_loadCANDIDATE(i) = max(max_rt_loadRNGW->CANDIDATE(i), max_rt_loadCANDIDATE(i)->RNGW,
        max_rt_loadCANDIDATE(i)->SERVING_BTS, max_rt_loadSERVING_BTS->CANDIDATE(i))
    for j = 1 to N
        max_rt_loadCANDIDATE(i) = max(max_rt_loadCANDIDATE(i),
            max_rt_loadCANDIDATE(i)->DRIFT_BTS(j), max_rt_loadDRIFT_BTS(j)->CANDIDATE(i))
    if (max_rt_loadCANDIDATE(i) ≤ max_rt_loadmin)
        max_rt_loadmin = max_rt_loadCANDIDATE(i)
    else
        drop candidate i from the MDC point candidate list
for i = 1 to N (excluding already dropped candidates)
    if (max_rt_loadCANDIDATE(i) > max_rt_loadmin)
        drop candidate i from the MDC point candidate list

```

Fig. 5

```

mdc_loadmin = 1 (or some other initialization)
for i = 1 to N (excluding already dropped candidates)
    if (mdc_loadCANDIDATE(i) < mdc_loadmin)
        mdc_loadmin = mdc_loadCANDIDATE(i)
    else
        drop candidate i from the MDC point candidate list
for i = 1 to N (excluding already dropped candidates)
    if (mdc_loadCANDIDATE(i) > mdc_loadmin)
        drop candidate i from the MDC point candidate list

```

Fig. 6

Node	MDC load (%)	Real time traffic loads (% of link capacity) towards neighbor nodes (maximum allowed RT traffic load: 80%)									
		A	B	C	D	E	F	G	H	I	J
A	75	-	50	-	-	-	-	-	-	-	30
B	70	25	-	60	-	-	40	-	-	-	-
C	65	-	30	-	30	40	-	-	-	-	-
D	60	-	-	15	-	-	-	-	-	-	-
E	45	-	-	20	-	-	-	-	-	-	-
F	55	-	20	-	-	-	-	50	-	-	20
G	65	-	-	-	-	-	25	-	40	30	-
H	40	-	-	-	-	-	-	20	-	-	-
I	75	-	-	-	-	-	-	15	-	-	-
J	60	15	-	-	-	-	10	-	-	-	-

Fig. 7

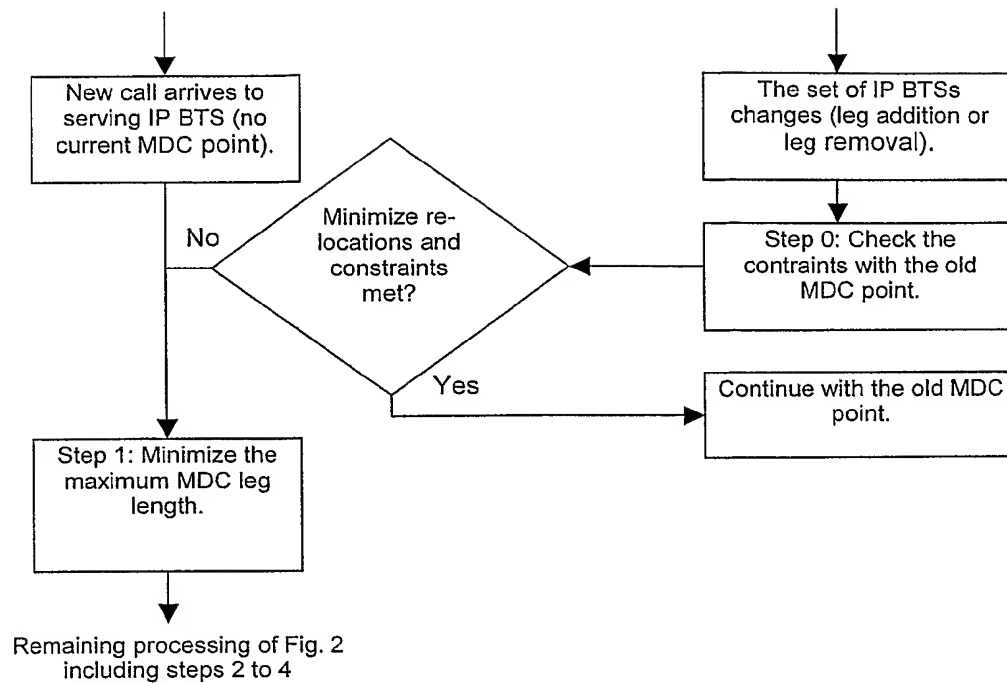
```

if (new connection)
  calculate the optimal MDC point
else
  if (initial [or stricter] constraints of the MDC point selection
    scheme met)
    continue using the current MDC point
  else
    calculate the optimal MDC point

```

Fig. 8

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**Fig. 9**

```

if (new connection)
    calculate the optimal MDC point
else
    if ( $max\_rt\_load_{Current\_MDC\_Point} \leq 0.9 * rt\_threshold$ )
        continue using the current MDC point
    else
        calculate the optimal MDC point
  
```

Fig. 10

INTERNATIONAL SEARCH REPORT

PCT/IB 02/01606

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04Q7/38 H04Q11/04 H04B7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 99 41850 A (NOKIA TELECOMMUNICATIONS OY ;AALTO RISTO (FI); KOHONEN PEKKA (FI);) 19 August 1999 (1999-08-19) abstract page 3, line 25 -page 5, line 18	1,22
A	US 6 198 737 B1 (ERNST DETLEF ET AL) 6 March 2001 (2001-03-06) cited in the application abstract column 2, line 23 - line 64	1,22
-/-		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

12 November 2002

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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